Mars Sample Return Concept Status

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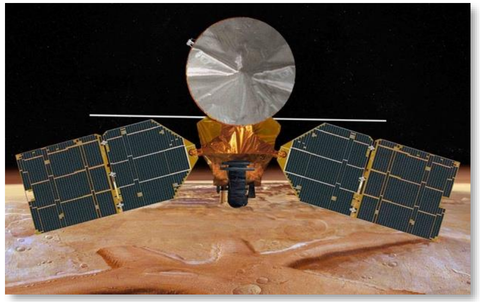
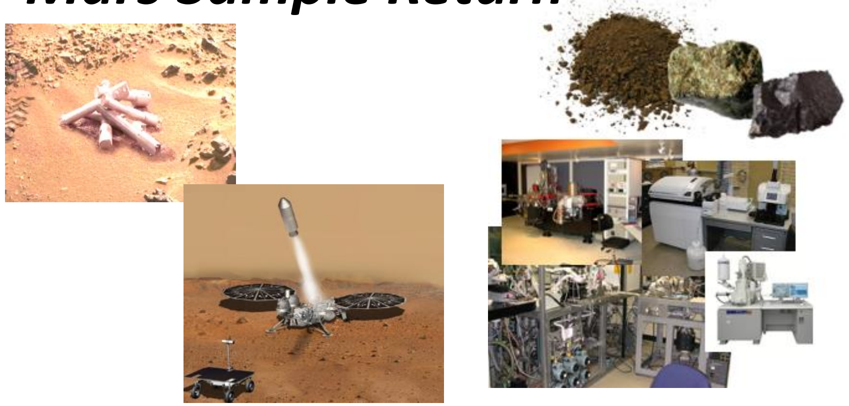
Science Motivation for Mars Sample Return

Orbital and In Situ Observations



- Exploration of Mars to date, from orbit and from the surface, has given us incredibly valuable insights into many aspects of Mars
- These insights have allowed us to pose new, far more detailed, questions

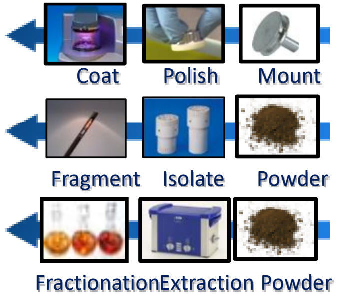
Mars Sample Return



- The Mars science community believes that the best next step to answering these questions is through analysis of returned samples in Earth laboratories

Advantages of Earth-based Laboratory Analysis:

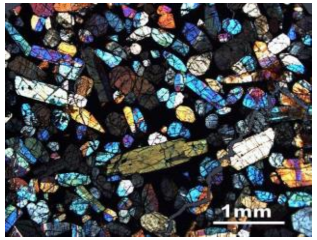
Access to sophisticated sample preparation



Access to multiple, diverse, and large instruments

Discovery-responsive investigation pathways

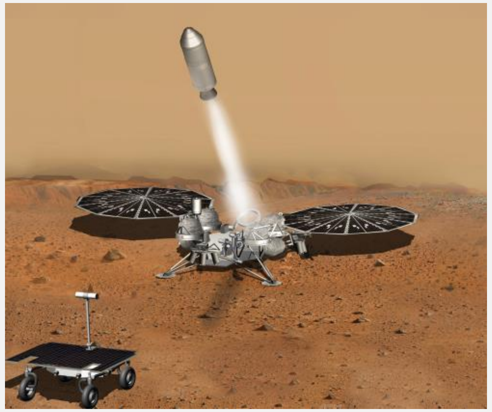
Greatly improved spatial focus/resolution



Campaign Architecture with MSR Flight Elements Under Study

Sample Caching Rover (Mars 2020)

- *Sample acquisition and caching*



Sample Retrieval Lander

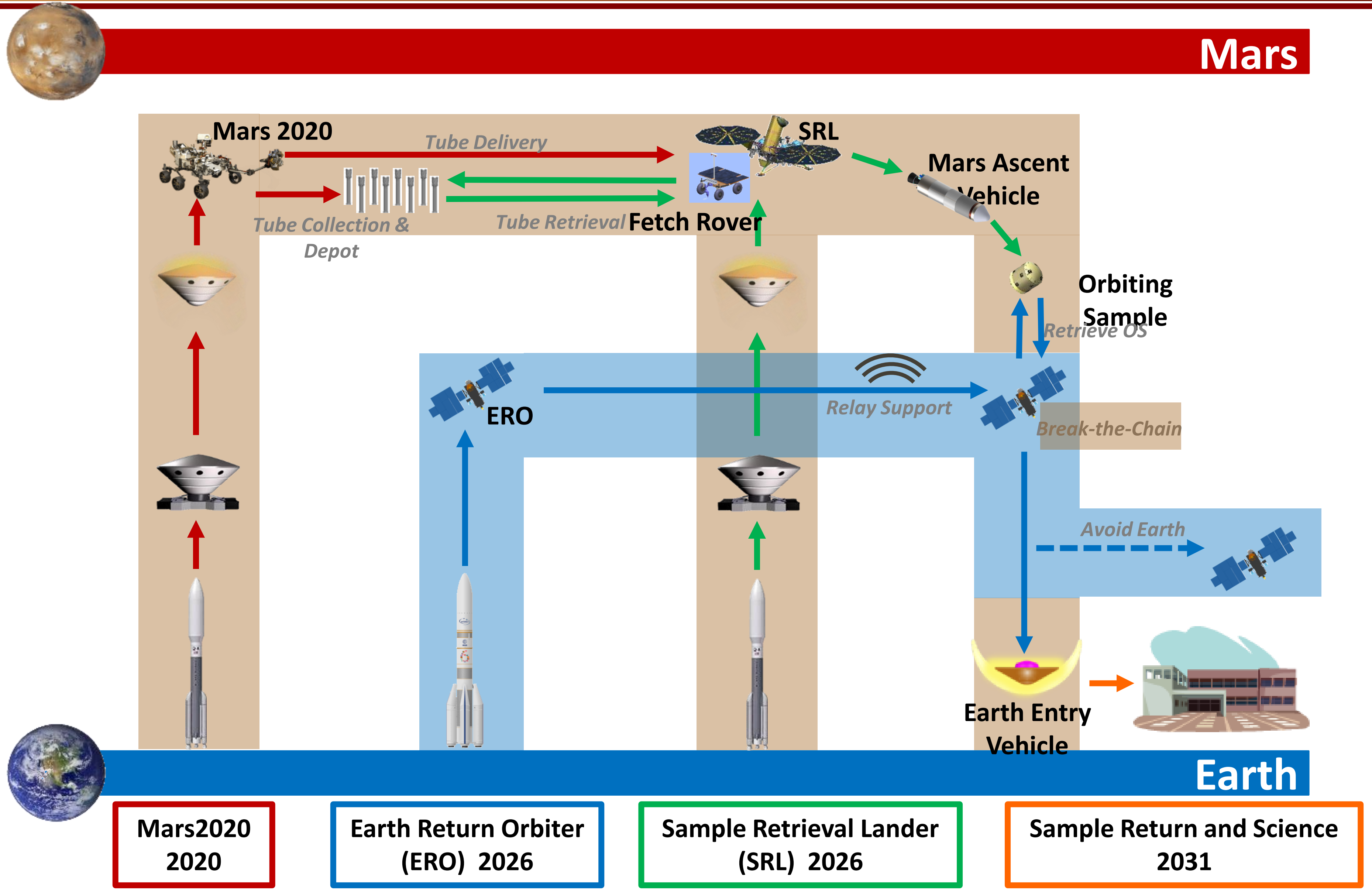
- *Fetch Rover*
- *Orbiting Sample container (OS)*
- *Mars Ascent Vehicle*

Earth Return Orbiter

- *Capture/Containment Module*
- *Earth Return Module*

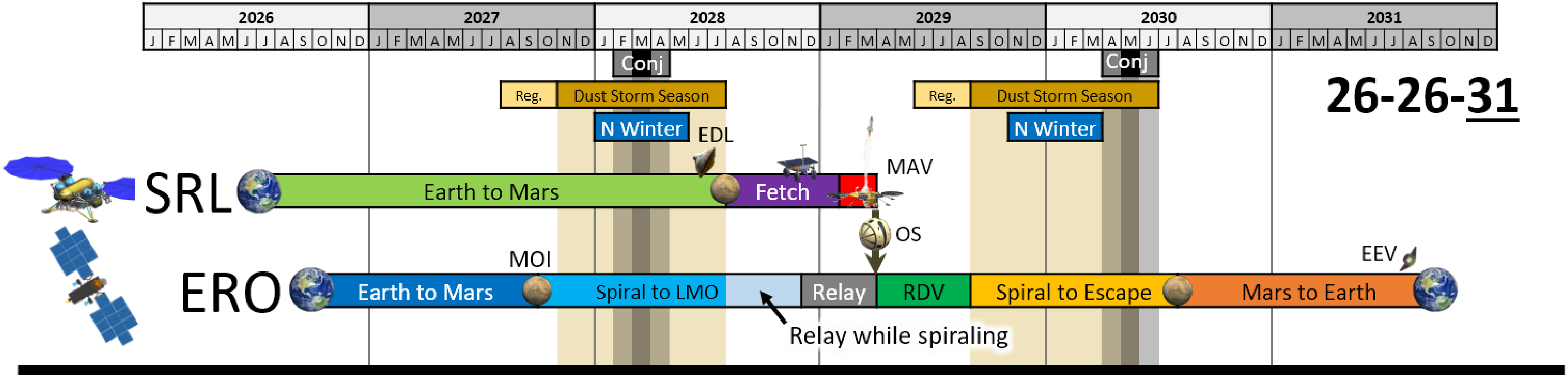
New MSR Flight Elements Under Study

Proposed MSR Campaign Strategy Concept



Pre-decisional information, for planning and discussion purposes only.

Notional Campaign Concept Timeline Under Study



26 – 26 – 31

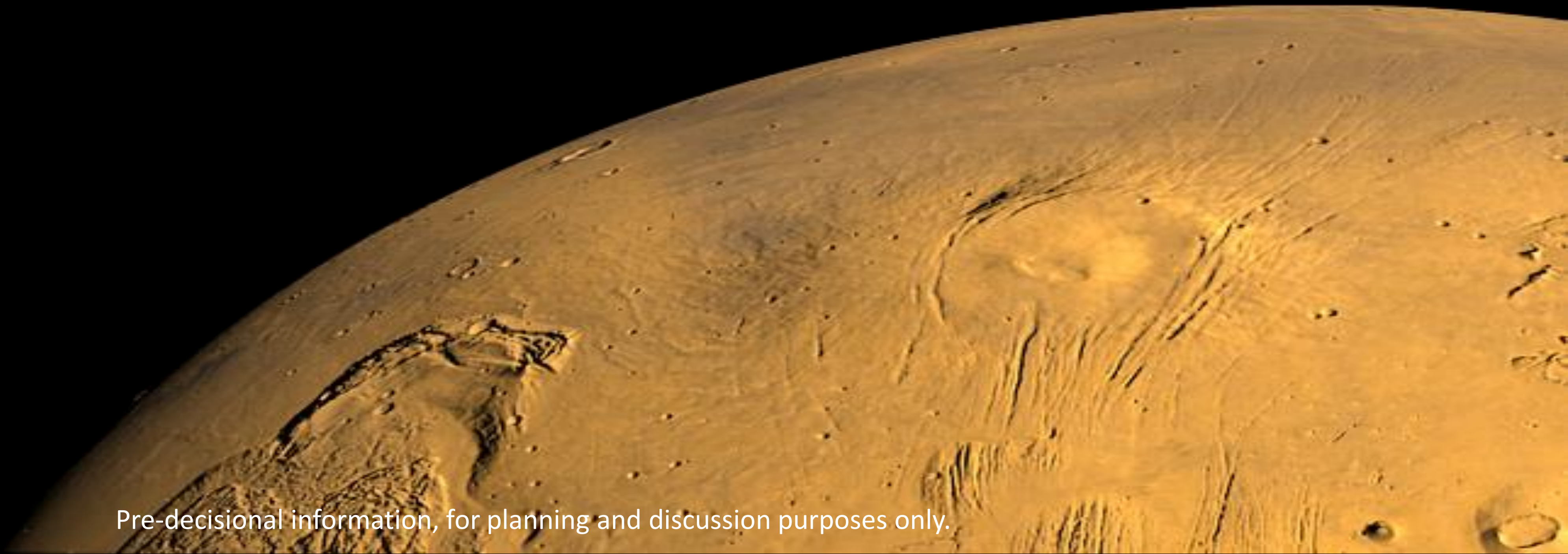
*Timeline is illustrative, not exact

SRL Launches in 2026

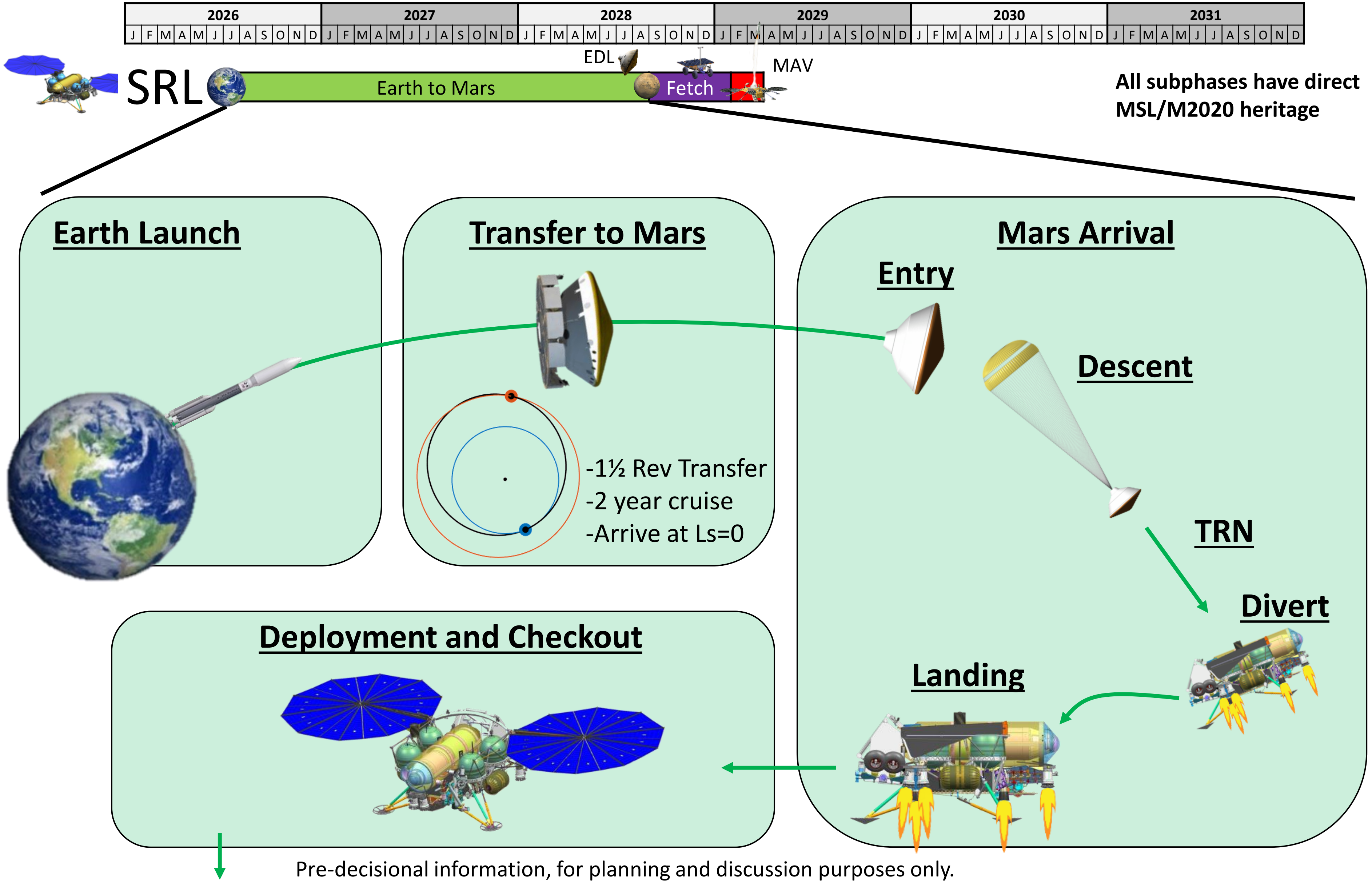
ERO launches in 2026

Samples are returned in 2031

MSR Sample Retrieval Lander (SRL) Major Element Concepts



SRL Cruise and EDL Concept



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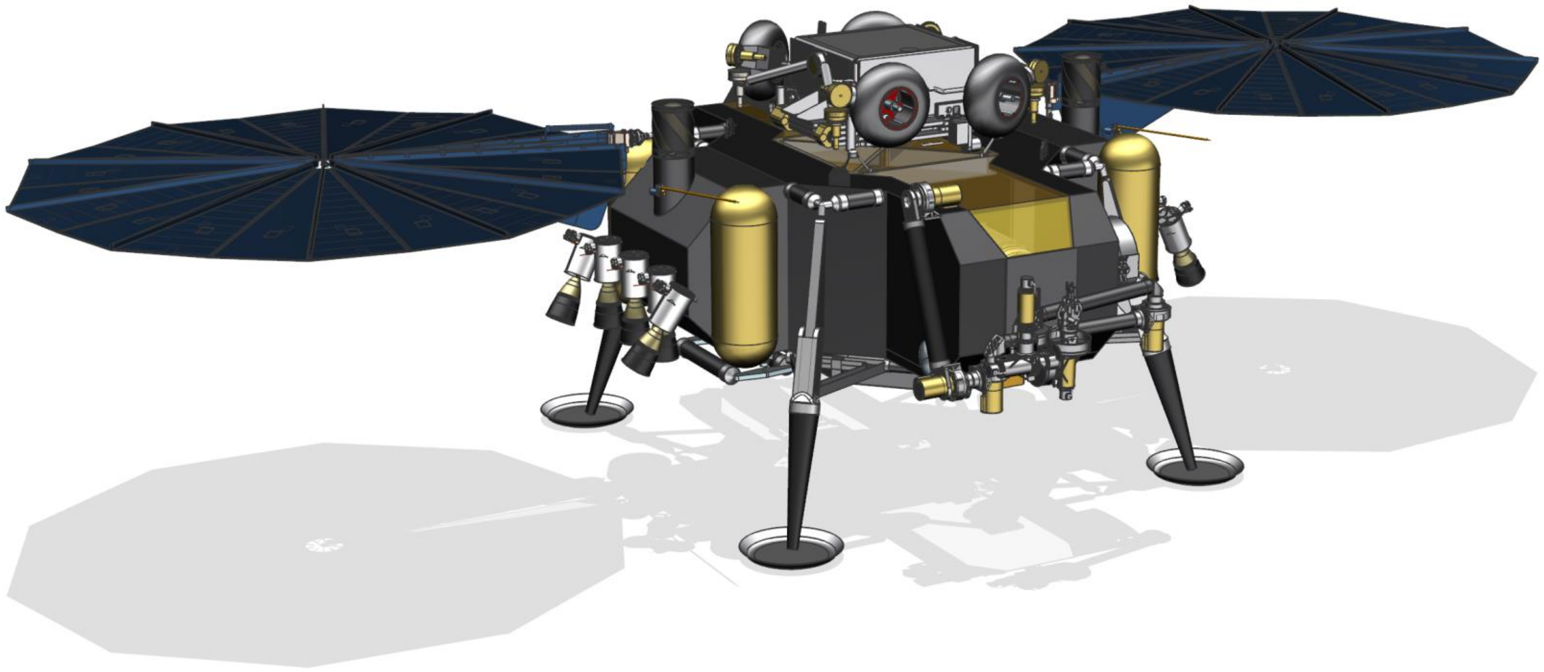
Sample Retrieval Lander (SRL) Key Trade Studies

- Lander design approach options evaluated: Skycrane vs Propulsive platform
- Lander trade key considerations
  - Leverage legacy systems
  - EDL capabilities heritage from MSL/Mars 2020
  - Solar power lander to minimize cost/complexity
  - Accommodation of SFR (~170 kg) and MAV (~450kg) and MAV launch system. Landed dry mass est: ~2100kg (PPL)
- Propulsive platform approach outperforms Skycrane in many key areas
  - Accommodates SFR and MAV with better volumetric clearances and mass margins

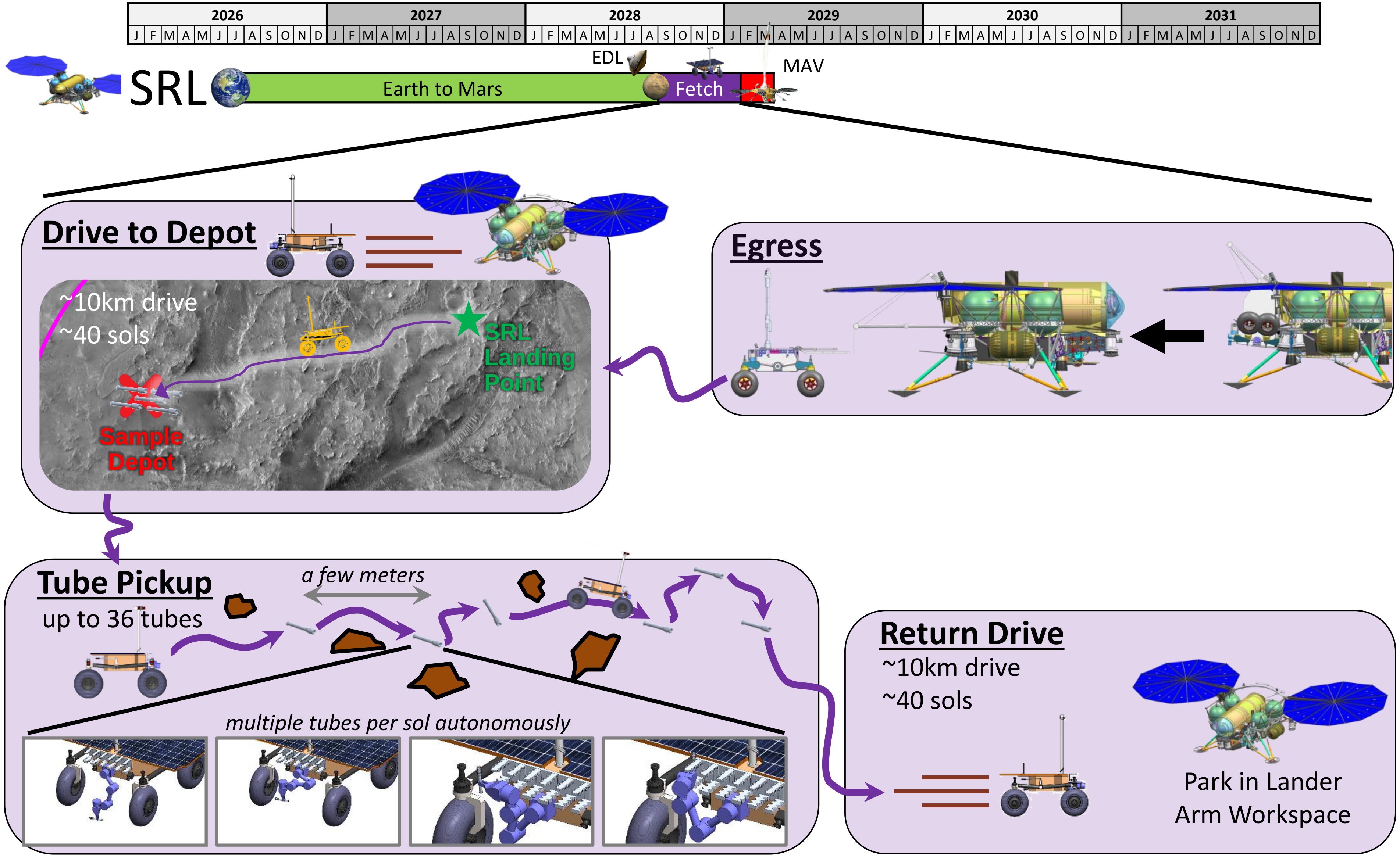
SRL Lander Latest Concept and Key Design Studies

- Accommodation of MAV, including launch/ejections system
- Accommodation of sample Fetch Rover (SFR), including egress
- MAV propulsion technology and vehicle design, including GNC performance and reliability
- OS and MAV Payload Assembly (MPA): Tube accommodation, tube transfer with STA, OS protection and ejection into Mars orbit
- Planetary protection design for OS cleanliness and implementation strategies



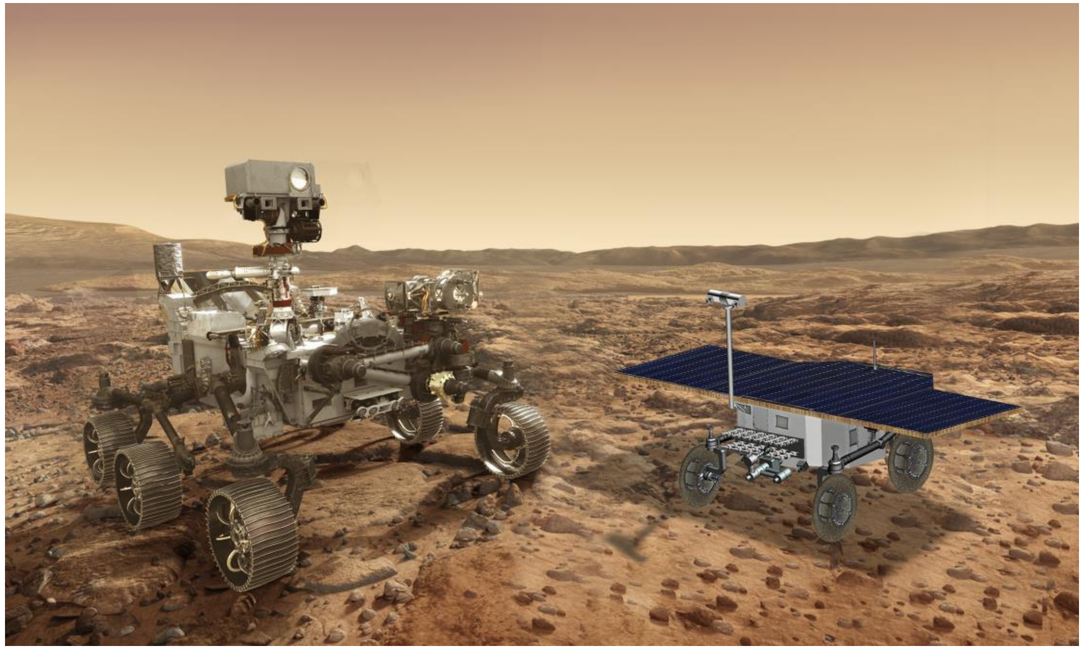
Propulsive Platform Lander

SFR Operations Concept

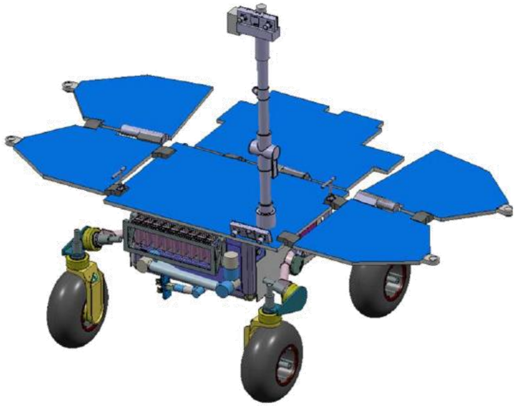


Dual Assets for Sample Tube Retrieval Under Study

- Two rover approach for sample tube retrieval provides mission robustness against M2020 extended life risk and SFR performance uncertainties
- Sample Fetch Rover (SFR):
  - Smaller, focused rover with fast traverse
  - Retrieve the M2020 strategically deposited cached sample tubes, return to SRL
  - SRF leverage technology of ExoMars rover with enhanced auto-navigation
  - Surface operation timeline management is crucial (duration is < 150 sols)
- Coupled con-op scenarios being studied on sample tube placement and retrieval strategies with Mars 2020 to optimize science return

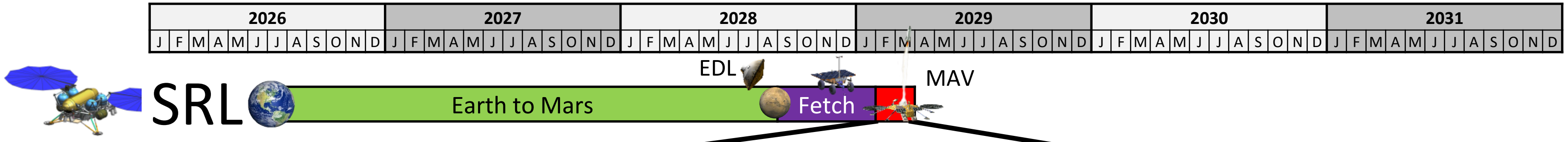


M2020 (1050 kg) and SRF (~170 kg)



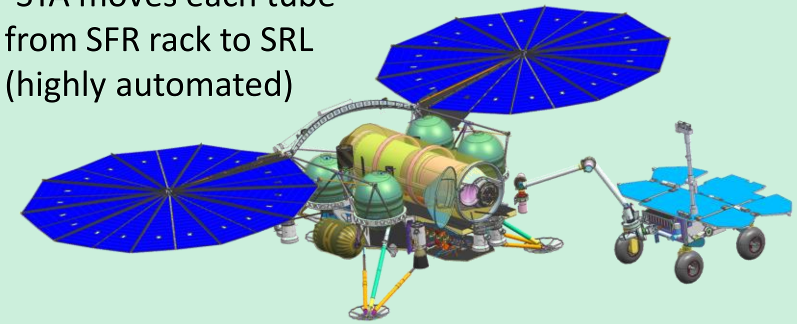
SRF ~2/3 size of MER w/4 wheels (NASA provided)

OS Loading and MAV Preparation Concept

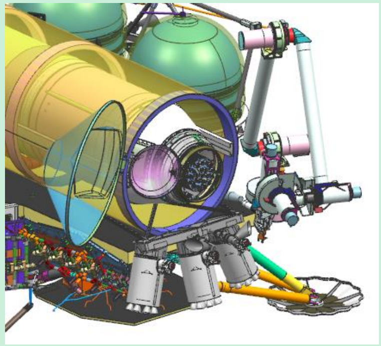


Transfer Tubes from SFR

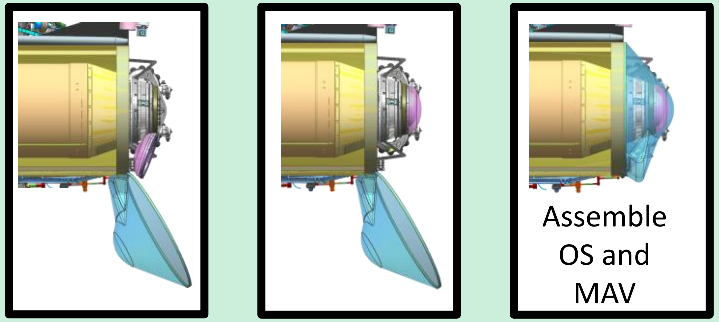
-STA moves each tube from SFR rack to SRL (highly automated)



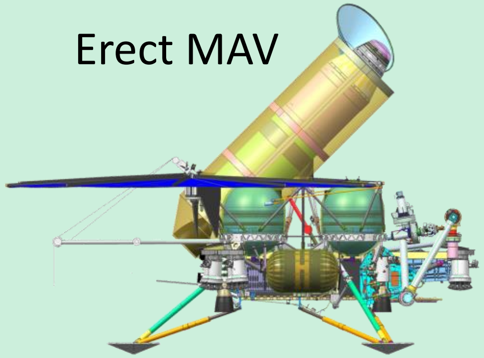
Insert tubes into OS



Prepare for MAV Launch



Erect MAV



GNC Calibrations

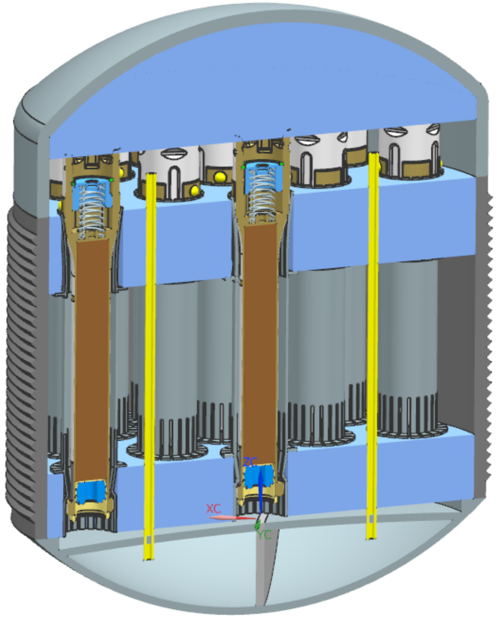
Heat MAV to AFT

Checkout Comm

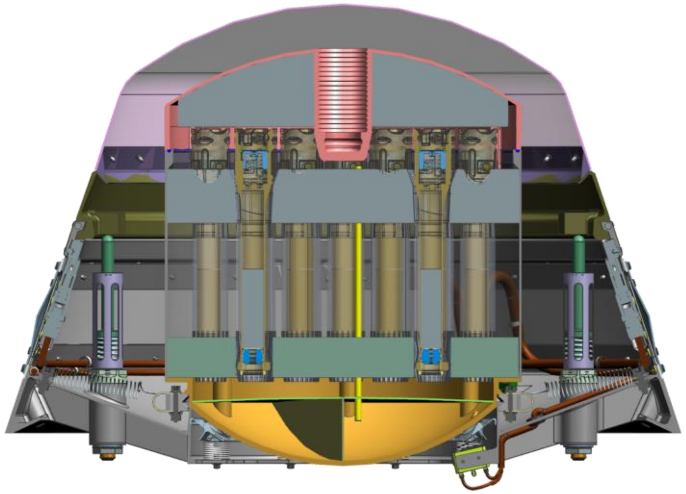
Orbiting Sample (OS) and MAV Payload Accommodation (MPA) Concepts

- OS and MPA design and performance drivers:
  - Number of sample tubes (10-40)
  - Ensure tube transfer compatibility with Sample Transfer Arm (STA)
  - Complies with MAV launch mass constraint
  - OS release, visibility for rendezvous and capture and processing by CCRS
  - Maintain tube integrity at Earth landing
- Options evaluated:
  - Wide range of OS sizes, shapes and designs optimizing for mass, tube transfer, support for Earth landing
  - Have developed designs that can accommodate 20-30 sample tubes which meet performance and mass constraints

Return Sample Tube Assembly (RSTA) 85 gm, 140 mm long

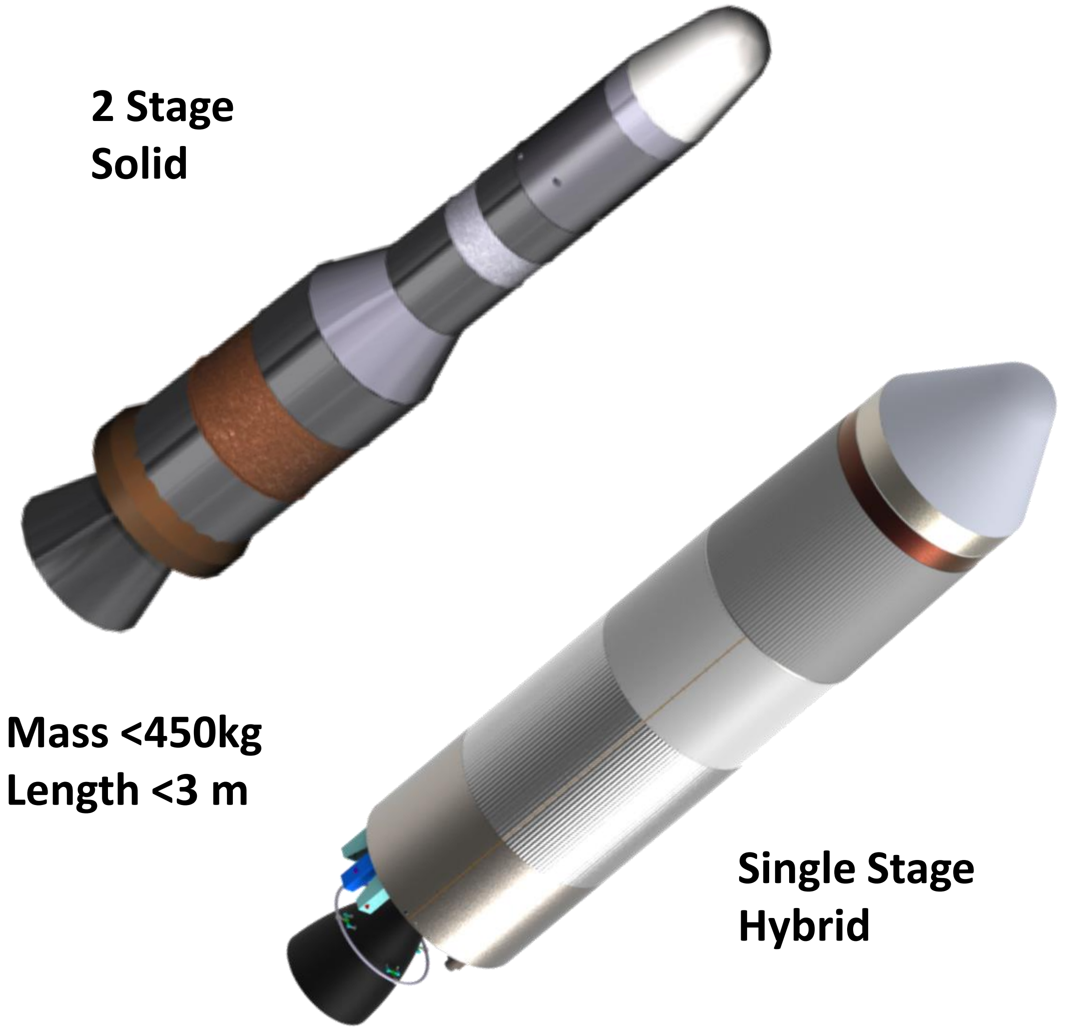


30 Tube OS an MPA

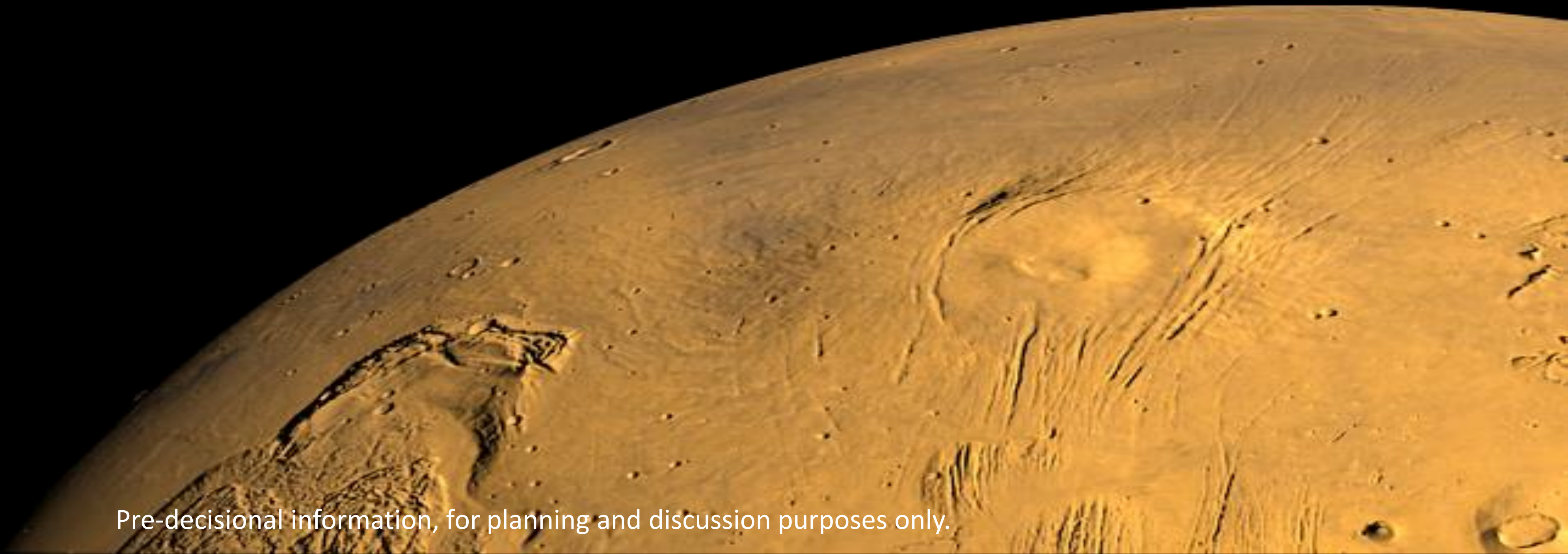


Mars Ascent Vehicle Trades Under Study

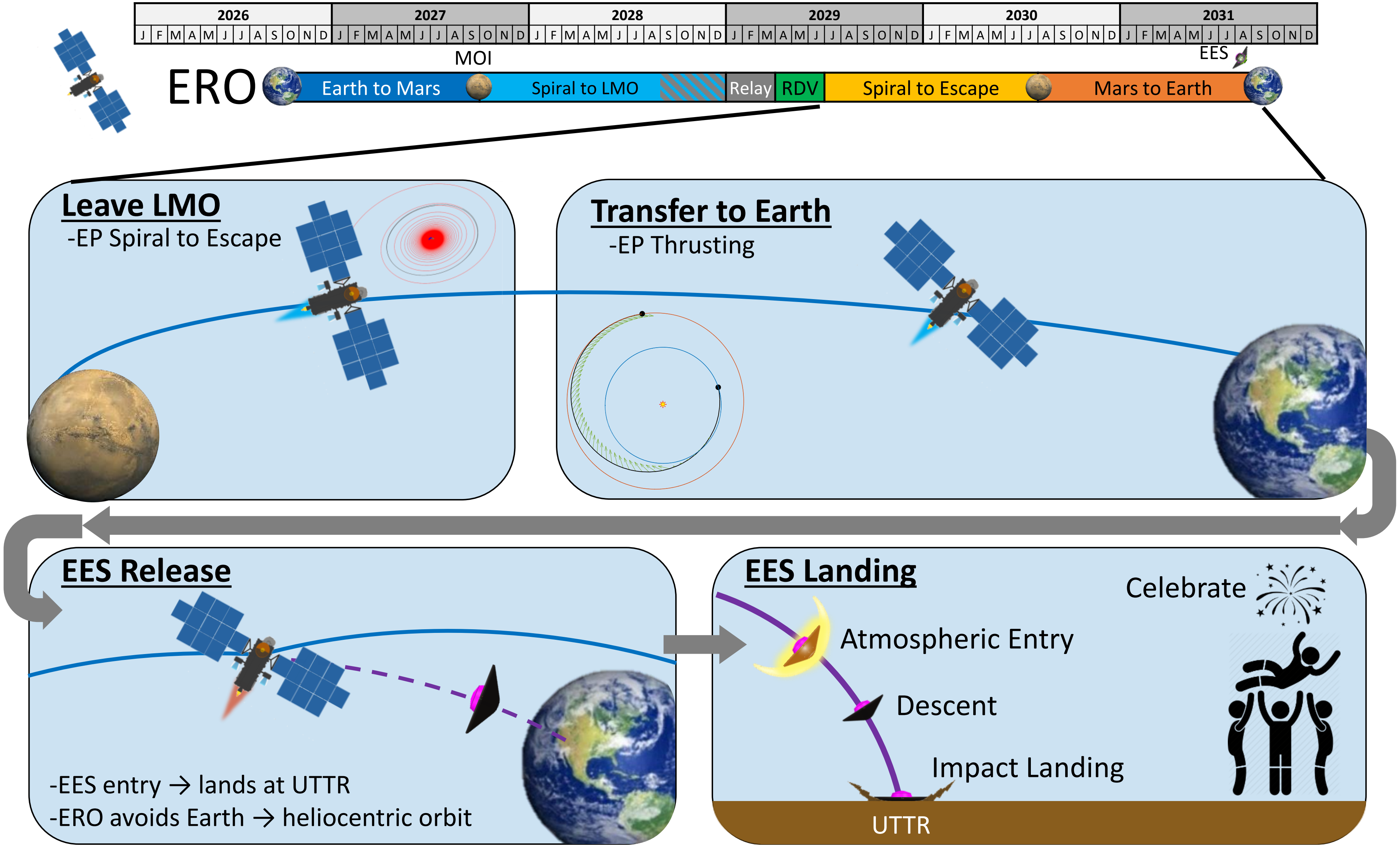
- MAV performance and technology drivers:
  - Launch OS into >300 km orbit, 25 deg inclination with moderately tight dispersion <1 deg.
  - Accommodate MPA/OS w/20-30 tubes, 16 kg
- Options evaluated:
  - Single stage to orbit hybrid with restart (new technology). Have conducted 6 motor development tests.
  - Two stage to orbit solid (update of heritage low temp. propellant)
  - Both vehicle designs are maturing to meet performance, mass and volume constraints
- Two stage solid showing lower technical and cost risk. Baseline to be decided after final tests to be completed by Nov.



MSR Earth Return Orbiter and Capture/Containment and Return Overview



ERO Earth Return and EES Delivery Concept



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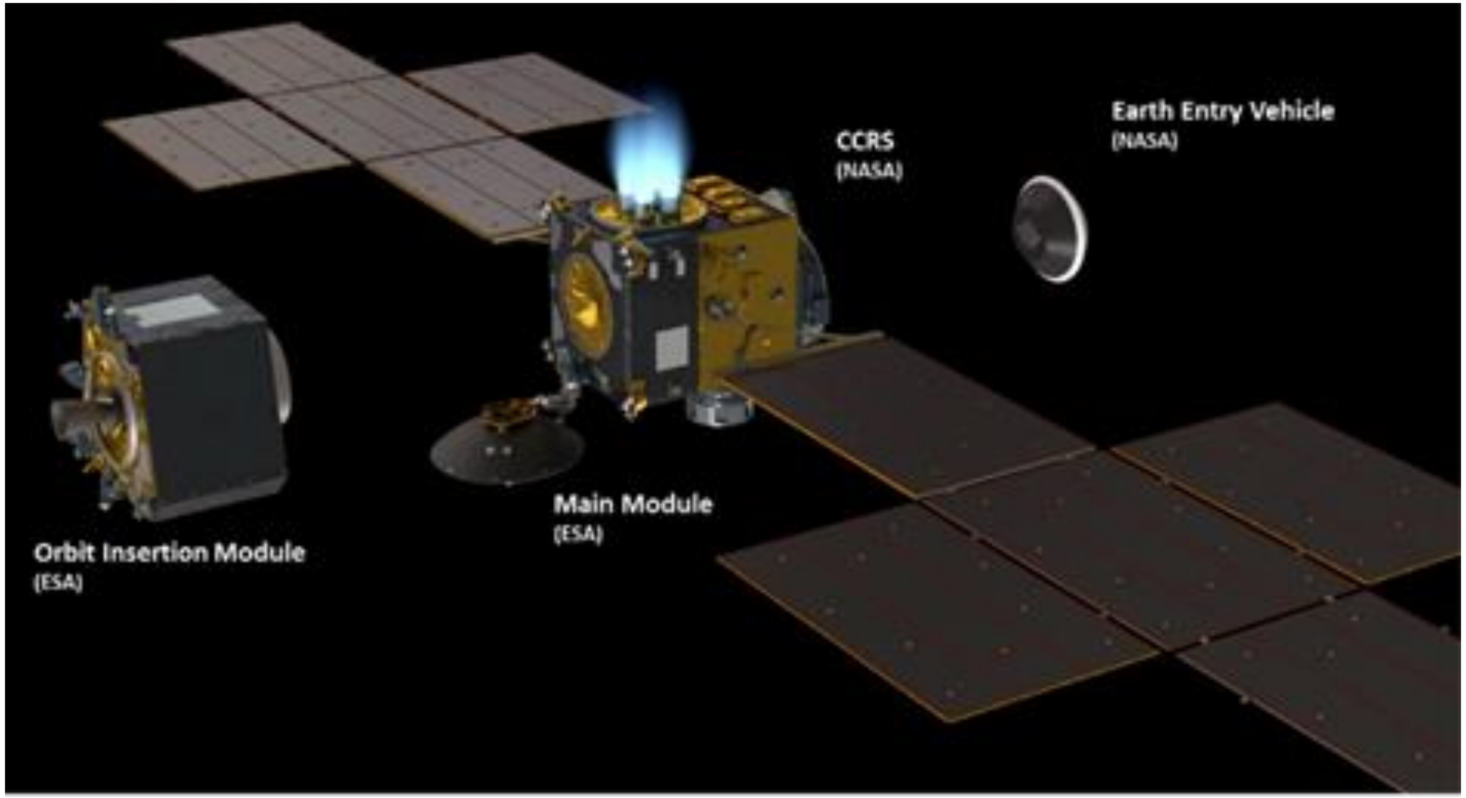
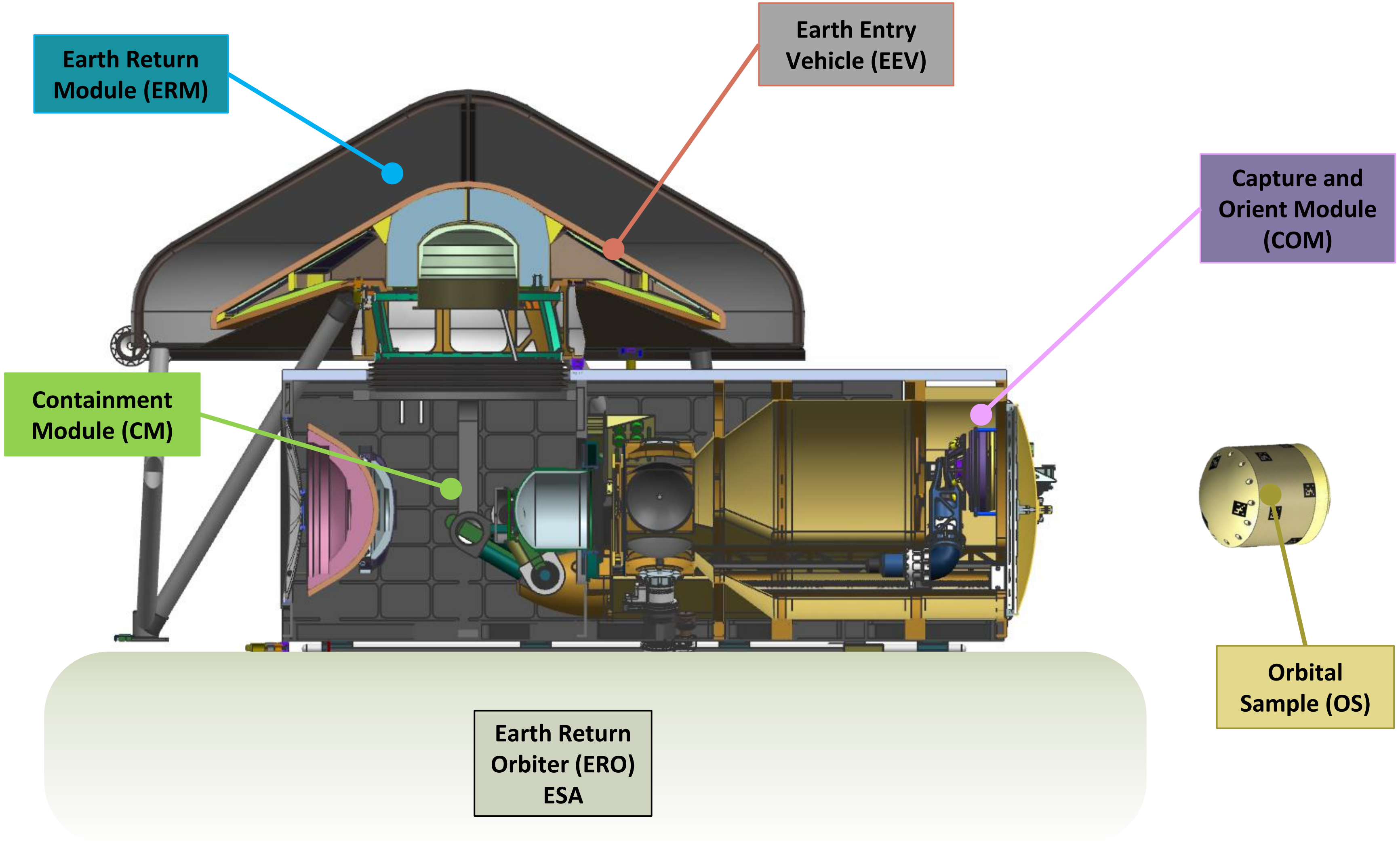
Earth Return Orbiter Being Studied By ESA

- Responsible for performing the round-trip mission and timeline and executing the following functions:
  - Telecommunications relay function for EDL and the SFR surface mission
  - Monitoring the MAV launch and conducting autonomous rendezvous and capture the OS by the CCRS
  - Supporting processing the OS containment and assembly of the EES in the CCRS
  - Return to Earth and release the EES to the precision targeting needed to land at the approved landing site; and then perform the collision avoidance maneuver after EES release
- ERO is under study by ESA through a competitive study process. Concepts being studied include launch on an Ariane 6.4, using a hybrid chemical and electrical propulsion system



Capture/Containment and Return System (CCRS) Concept

- Performance drivers
  - OS capture, orientation
  - Containment including "Break the Chain" of contact of Mars materials between Mars and Earth
  - Assemble OS and containment vessels into EEV, making EES
  - Spin up and release EES
  - Launch mass 500, return mass (primarily EES) 200 kg
- Current concept is meeting performance drivers with good mass margins



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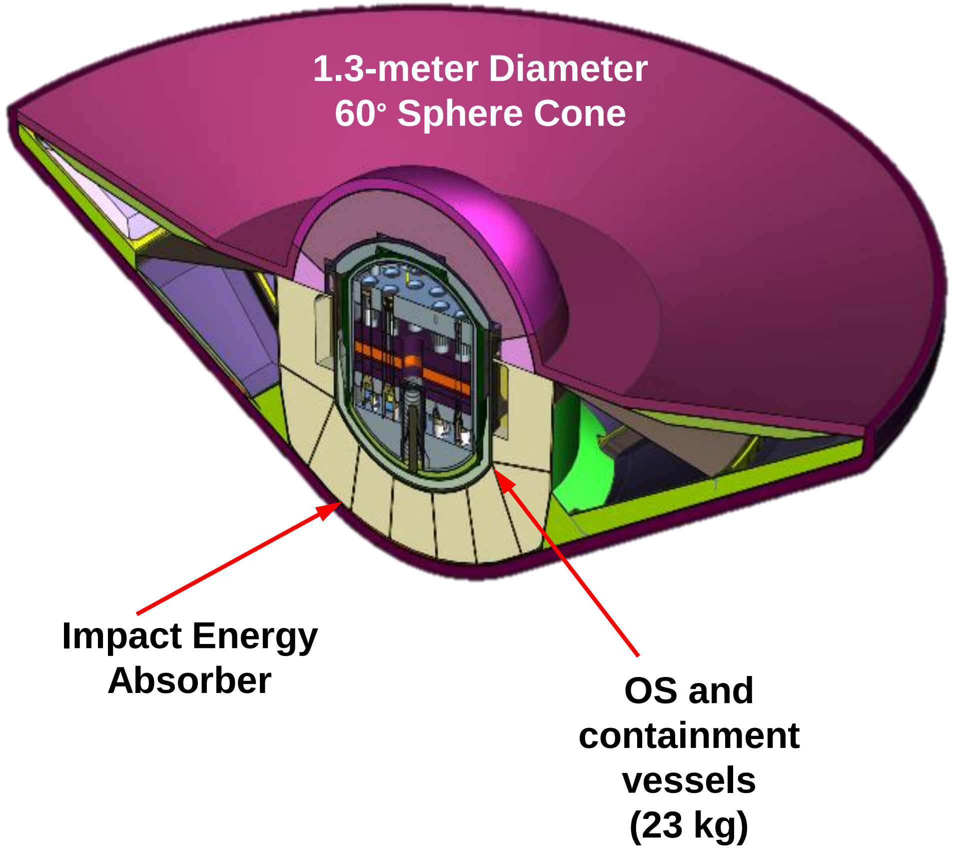
Earth Entry System (EES) Concept

- EES is comprised of the Earth Entry Vehicle (EEV) and the OS and containment vessels
- EEV performance and technology drivers:
  - Entry velocity <12 km/s
  - Fully passive, no parachute (as compared to Stardust and Genesis)
  - Maintain OS and sample tube integrity for landing at approve US landing site
  - Mass: <100 kg
- Options evaluated:
  - Hot structure or Cold Structure
  - Thermal protection system PICA or HEEET
- Cold structure with HEEET is showing smaller Earth entry landing ellipse due to ability to perform at steeper entry flight path angles and likely better MMOD damage tolerance.



Summary

- Mars Sample Return campaign and design studies at NASA and ESA are proceeding well
- Key architectural-level design trades and lower level design studies are converging toward a campaign reference concept